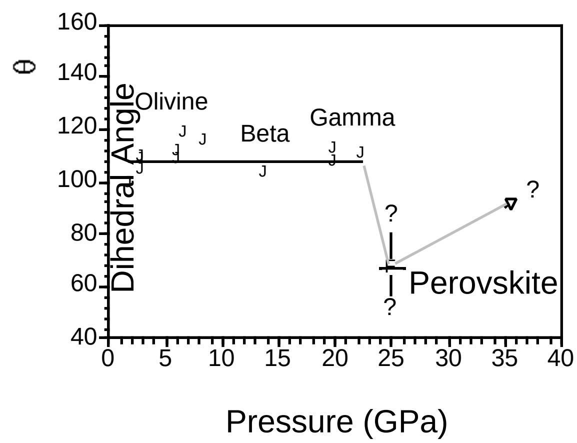
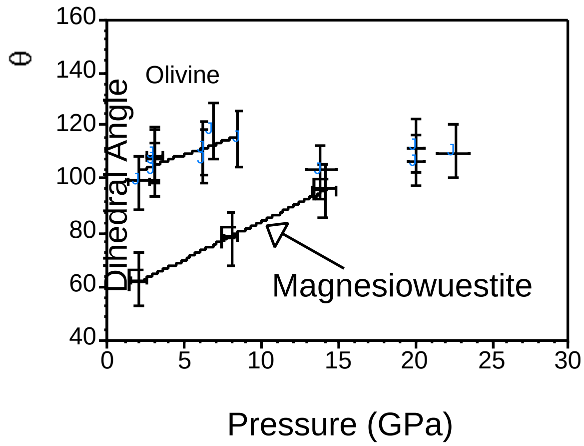
EXPERIMENTAL CONSTRAINTS ON PERCOLATIVE CORE FORMATION AT LOWER MANTLE CONDITIONS. C. B. Agee and M. C. Shannon, Department of Earth and Planetary Sciences, Harvard University, Cambridge, MA 02138, agee@eps.harvard.edu.

Summary. We report here new measurements on the wetting of lower mantle minerals by iron alloy melts at high pressure. In a previous study we found that the wetting of upper mantle minerals by iron alloy melts at high pressures is incomplete, implying that percolative core formation at depths above 600 km in the early Earth was inefficient (Shannon and Agee, 1996). Therefore, we concluded that some silicate melting was required to segregate the iron alloy of the core of the Earth from the silicate upper mantle. At lower mantle pressures, however, there is a significant mineralogical change in the primary silicates from olivine (or one of its polymorphs) and pyroxene to perovskites and magnesiowuestite. Our preliminary results suggest that a perovskite dominated mineral assemblage may be more readily wetted by molten iron alloys, which may in turn allow efficient fluid drainage in the lower mantle during core formation. The new data also reveal a positive pressure effect on the values of the dihedral angles at magnesiowuestite-molten iron alloy triple junctions. If a similar pressure effect on dihedral angle holds for perovskite, then wetting by molten iron alloy may be restricted to the shallow lower mantle.

Experimental. Two sets of experiments were performed -- one to examine the wetting of $(Mg,Fe)SiO_3$-perovskite, and the second to examine the wetting of magnesiowuestite. The perovskite experiments were performed at 25 GPa and 1850°C on a starting material of finely abraded Homestead chondrite. At run conditions, the Fe-Ni metal and Fe-Ni sulfide phases of Homestead melt and combine to form a liquid alloy interspersed in a silicate matrix. At lower mantle pressures, the silicates of Homestead recrystallized to form predominately $(Mg,Fe)SiO_3$-perovskite, with lesser amounts of magnesiowuestite, $CaSiO_3$-perovskite, and garnet. To characterize the wetting behavior, dihedral angles at solid-solid-"melt" (quenched sulfide glass) triple junctions were measured. Preliminary results yield a median distribution for dihedral angles of approximately 67°. This value is slightly above the 60° cutoff required for complete fluid percolation. This result is significantly lower than the dihedral angles of approximately 108° measured in upper mantle mineral assemblages (see figure below). There are generous error bars associated with the perovskite measurements because a strong central peak was absent in the distribution of measured dihedral angles. More experiments are underway to confirm this initial finding.



The second set of experiments were performed at pressures from 2 to 14 GPa at 1900°C on a composition of magnesiowuestite and iron sulfide. Here we observed a strong pressure effect on dihedral angle under isothermal conditions (see figure below). At low pressure (2 GPa) the dihedral angle was approximately 62° and the magnesiowuestite matrix appeared to be extensively wetted by the molten alloy. At higher pressures the dihedral angle was significantly higher than 60° indicating that some alloy was isolated in the magnesiowuestite matrix. The increase in dihedral angle suggests that the surface tension values of the molten alloy and magnesiowuestite approach each other at high pressure. This distinct pressure effect seen in magnesiowuestite now lends support for similar behavior observed in olivine matrices in our earlier study. Further investigations are underway to examine the pressure effect on magnesiowuestite wetting in the range 15-25 GPa.



Discussion. It is clear that both pressure and mineralogy have important effects on dihedral angles and the wetting behavior of molten iron alloy in the mantle. In contrast to earlier predictions (Ringwood and Hibberson, 1991), pressure works against wetting of silicates and oxides. There may however, be certain conditions and mineralogies in the mantle where complete wetting occurs and percolative alloy melt extraction is efficient. The most likely site for complete drainage may be in a perovskite dominated lower mantle. On the other hand, higher pressures in the deeper lower mantle may cause a percolation shut-off. Hence, we speculate that the mantle could be non-percolative at the top and bottom, with a percolative layer existing in the mid-mantle. How this configuration might affect core formation requires further study, but it seems likely that gravitational instabilities would develop between an iron-laden upper mantle and a shallow lower mantle devoid of core fluid.

References

Ringwood, A. E. and W. Hibberson, Solubilities of mantle oxides in molten iron at high pressures and temperatures: implications for the composition and formation of the Earth's core, *Earth Planet. Sci. Lett.*, 102, 235-251, 1991.

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